CHAPTER 6

NONSTRUCTURAL ALTERNATIVES

6-1. Salt Marshes.

a. General. Shore erosion is a common problem in the bays, sounds, and estuaries of the coastal United States. A wide variety of structures have been developed and used to control this erosion. However, due to environmental objections and economic limitations it is often impractical to use even the most innovative of these structures. This fact is particularly true for relatively low wave-energy areas where erosion may be costly but has not yet reached catastrophic proportions. Low-cost, nonstructural techniques are available for controlling erosion in salt and brackish water, low wave-energy areas of contiguous United States using native marsh plants. Vegetation, where feasible, is usually lower in cost than structures and may be more effective.

(1) Coastal marsh vegetation.

(a) A coastal marsh is an herbaceous (plants lacking woody stems) or grassy plant community found on the part of the shoreline which is periodically flooded by salt or brackish water. A number of species in the grass family (Poaceae), sedge family (Cyperacae), and rush family (Juncaceae) commonly form coastal marshes.

(b) Coastal marshes occur naturally in the intertidal zone of moderate- to low-energy shorelines along tidal rivers and in bays and estuaries. These marshes may be narrow fringes along steep shorelines but can extend over wide areas in shallow, gently sloping bays and estuaries. Historically, such lands were extensive and widely distributed along the Atlantic, Florida peninsula, Gulf, and Pacific coasts of the United States before development by man.

(c) There are two major groups of coastal salt marshes in the United States, based on physiographic differences--marshes of the Atlantic, Florida peninsula, and Gulf coasts (the eastern region) and those characteristic of the northern and southern Pacific coasts (the western region). The eastern marshes usually form on a gently sloping coast with a broad continental shelf, under conditions of a sea slowly rising relative to the land. Western marshes are mostly formed in relatively narrow river mouths which drain almost directly onto a steeply sloping continental shelf along a slowly emerging coastline (Cooper 1969). Consequently, the western estuaries and their marshes are more limited in development than those of the east and tend to mature more rapidly. There are two types of coastal salt marshes: the regularly flooded low marsh, which is considered to be the most valuable and usually the most essential to erosion control; and the irregularly flooded high marsh.

(2) Erosion control plantings.

(a) With the use of agricultural techniques, plants can often be established on shorelines where natural processes of invasion have failed to produce plant cover. Marshes established in this manner may greatly improve the shore's stability and resistance to erosion. This erosion control alternative has been used successfully for many years in the United States. For example, in the winter of 1928, a property owner on the eastern shore of Chesapeake Bay planted smooth cordgrass (Spartina alterniflora) along more than 1 kilometer (0.5 mile) of shoreline in an attempt to reduce erosion. This shoreline has remained stable for more than 50 years and is the oldest reported example of shore stabilization with salt marsh vegetation in the United States (Knutson et al. 1981) as shown in Figure 6-1. Similarly in 1946, a landowner on the Rappahannock River in Virginia graded an eroding shoreline and planted several varieties of salt-tolerant plants. This planting has prevented erosion for 40 years (Phillips and Eastman 1959, Sharp and Vaden 1970, Sharp et al. 1981).

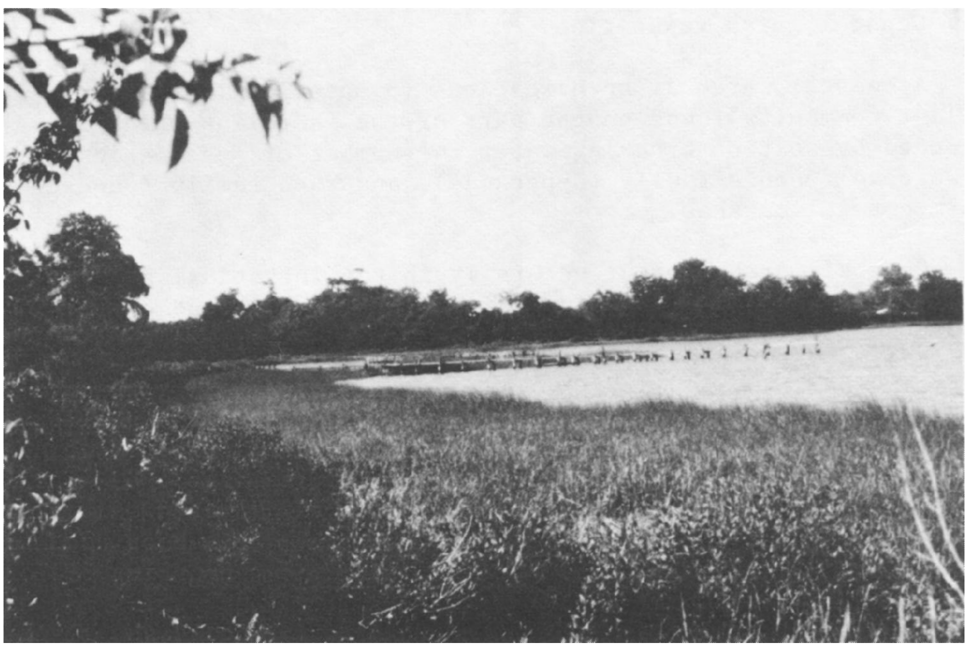


Figure 6-1. Oldest reported salt marsh planting in the United States

(b) Researchers in other coastal regions have found that shoreline stabilization with plants can be successful--Garbisch et al. (1975) in Chesapeake Bay; Webb and Dodd (1978) in Galveston Bay, Texas; Allen et al. (1986) in Mobile Bay, Alabama; Newcombe et al. (1979) in San Francisco Bay, California; and Newling and Landin (1985) at Corps sites in a number of coastal Districts. Based on these studies, design criteria for vegetation stabilization projects were developed (Knutson 1976 and 1977a-b, Knutson and Woodhouse 1983, Allen and Webb 1983, Allen et al. 1984, Webb et al. 1984). The US Army Engineer

Waterways Experiment Station (1978) conducted a nationwide study program on marsh establishment on dredged material in the mid-1970's as part of the Dredged Material Research Program, which resulted in design criteria for marsh development. This program has continued to the present under the Dredging Operations Technical Support Program to include all types of wetland development as well as erosion control in moderate wave energies using vegetation (Landin 1986).

(c) Hall and Ludwig (1975) evaluated the potential use of marsh plants for erosion control in the Great Lakes. They concluded that there were few natural areas suitable for this method of shore protection because there are few sheltered shorelines. Marsh plantings are also subject to winter icing conditions and fluctuating lake levels in this region. Marsh vegetation can be established behind protective structures in the Great Lakes (Landin 1982). However, vegetation can be used to stabilize upland areas (Hunt et al. 1978, Pennington 1986). The roots of terrestrial plants add stability to the soil, retard seepage, and reduce surface runoff (Great Lakes Basin Commission 1978, Gray 1974 and 1975, Dai et al. 1977). Information on surface erosion and various techniques for its control (dewatering, slope grading, and planting ground cover species) are available from EM 1110-2-5026, US Army Engineer Waterways Experiment Station (1986), the US Soil Conservation Service, or from county agriculture extension agents.

(d) In Alaska, a relatively short-growing season, broad tidal ranges, high-energy conditions, and icing prevent the use of salt marsh vegetation for erosion control, and only one site is known to exist. This alternative has not been used in the bays and estuaries of Hawaii.

(3) Planting guidelines.

(a) For erosion control projects, the intertidal zone is the most critical area to be planted and stabilized. If a healthy band of intertidal marsh can be established along a shore, revegetation of the slope behind it will occur through natural processes. Four species of pioneer plants have demonstrated potential in stabilizing the part of the intertidal zone which is in direct contact with waves: smooth cordgrass (<u>Spartina</u> <u>alterniflora</u>) along the Gulf and Atlantic coasts, Pacific cordgrass (<u>Spartina</u> <u>foliosa</u>) on the Pacific coast from Humboldt Bay south to Mexico, and Lyngbye’s sedge (<u>Carex</u> <u>lyngbyei</u>) and tufted hairgrass (<u>Deschampsia</u> <u>caespitosa</u>) in the Pacific Northwest (Smith 1978). A number of wetland plants colonize the freshwater/intertidal zone (Landin 1978, Lunz et al. 1978).

(b) The width of the substrate at an elevation suitable for plant establishment will determine in part the relative effectiveness of the erosion control planting. A practical minimum planting width for successful erosion control is 6 meters (20 feet) (Knutson et al. 1981). On the Atlantic and Gulf coasts, marsh plants will typically grow in the entire intertidal zone in microtidal areas and to mean tide where tidal ranges are broader. Marsh plants seldom extend below the elevation of mean tide on the southern Pacific coast or below lower high water in the Pacific Northwest. Because of these elevational constraints, the more gradual the shore slope, the broader the potential planting width. On steeply sloping shores, there may be little area suitable for planting. If the potential planting area is not 6 meters (about 20 feet) in width, the shore must be sloped or backfilled to extend it. Backfilling must be done enough in advance of planting to allow for settling and firming of the soil.

(c) Salt marsh plants rely heavily on exposure to direct sunlight and will not grow in shaded areas. Therefore, any overstory of woody vegetation present at a site should be cleared above the planting area and landward to a distance of 3 to 5 meters (10 to 15 feet). However, should the woody overstory be desirable wetland plants such as mangroves, they should not be cleared, but worked around to prevent their loss.

(d) Vegetative transplants are used for erosion control planting instead of seeding which is not likely to be effective on sites subject to erosion. Vegetative transplant types include: sprigs, stems with attached root material; pot-grown seedlings; or plugs, root-soil masses containing several intact plants dug from the wild. Sprigs are the least expensive to obtain and easiest to handle, transport, and plant. They may be obtained from field nurseries, planted at least a year in advance, or collected from young marshes or the edges of expanding established marshes. Pot-grown seedlings are expensive to grow and plant, more awkward to handle and transport, but relatively easy to produce and transplant. They are superior to sprigs for late season planting. Plugs are the most expensive to obtain, difficult to transport, and probably used only when no other sources are available. The Soil Conservation Service may be helpful in locating and obtaining plant materials. A conservationist for the State Soil Conservation Service is located in all the state capitals.

b. Role in Shore Protection.

(1) Marsh plants perform two functions in abating erosion. First, their aerial parts form a flexible mass which dissipates wave energy. As wave energy is diminished, both the offshore transport and the longshore transport of sediment are reduced. Dense stands of marsh vegetation may even create a depositional environment, causing accretion rather than erosion of the shoreface. Second, many marsh plants form dense root-rhizome mats which add stability to the shore sediment. This protective mat is of particular importance during severe winter storms when the aerial stems provide only limited resistance to the impact of waves.

(2) Wave attenuation in marshes has not been studied extensively. Wayne (1975) measured small waves passing through a smooth cordgrass marsh at Adams Beach, Florida, and Webb et al. (1984) measured wave attenuation in a human-made marsh in Mobile Bay, Alabama. Knutson et al. (1982) conducted a series of field experiments measuring wave attenuation in natural salt marshes. Knutson found that a 15-cm (0.5-foot) wave experienced a 72 percent energy loss while traversing 5 m (15 feet) of coastal marsh. As the wave energy impacting the shore is reduced, there is increased potential for sediment

deposition and decreased potential for erosion. Woodhouse et al. (1974) measured sediment deposition resulting from marsh plantings and reported the deposition at 15 to 30 cm (0.5 to 1 foot) of sediment along three planted profiles at Snow's Cut, North Carolina, during a 30-month period.

(3) Studies have shown that plant roots do significantly increase soil stability (Gray 1974), In these studies the shear strength of vegetated soils was as much as two and three times greater than unvegetated soils. In addition, the shear strength of soils was higher when the volume fraction or weight density of the root system was greater.

c. Physical Considerations. The planting of shore vegetation is accomplished with a minimum of equipment and physical disturbance. When erosion control plantings are successful, they create a region of sediment deposition along the shoreline and reduce erosion.

d. Water Quality Considerations.

(1) Salt marshes have substantial absorptive capacities for potential pollutants such as nitrogen, phosphorus, and heavy metals (Williams and Murdock 1969, Woodhouse et al. 1974). Increased growth of salt marsh species in response to nutrients has been noted at several locations. Apparent recovery of applied nitrogen may be as high as 40 to 60 percent in shoot growth alone (Woodhouse et al. 1974 and 1976), a value that compares favorably with upland field crops. The potential for substantial recycling of nutrients between salt marshes and estuaries exists. The absorption, conversion, and recycling capabilities of marsh plants offer potential opportunities for water purification (Woodhill 1977).

(2) There has been concern expressed that intertidal marshes planted on polluted sediments may be a source for release of potentially toxic heavy metals to estuarine systems and the ocean. This matter is a subject of extreme complexity. In general, the release of heavy metals is not a major concern for shore stabilization projects unless sediments with high levels of heavy metals are used to grade the site prior to planting (Gunnison 1978). In this case, the issue of heavy metal release should be resolved on a case-by-case basis. However, it is also advisable to consider this issue when sizable shore stabilization projects are proposed for areas with highly polluted sediments.

e. Biological Considerations.

(1) Marsh ecology.

(a) Salt marshes are valued as sources of primary production (energy), as nursery grounds for sport and commercial fishery species, and as a system for storing and recycling nutrients. Once established, erosion control plantings function as natural salt marshes and gradually develop comparable animal populations (Cammen 1976, Cammen et al. 1976, Newling and Landin 1985).

(b) Only about five percent of the biomass of a given salt marsh is consumed while the plant material is still living. Grasshoppers and plant hoppers graze on the grass and are, in turn, eaten by spiders and birds, Direct consumption of rhizomes and culms of marsh grasses by waterfowl may be significant locally near waterfowl wintering grounds (Lunz et al. 1978). Periwinkles graze on algae growing on the grass. The pathway of energy flow is believed to move through the detrital food chain. Dead grass is broken down by bacteria in the surrounding waters and on the surface of the marsh. This process greatly decreases the total energy content but increases the concentration of protein, thereby increasing the food value. Some detrital particles and microalgae are eaten by a variety of deposit and filter feeders such as fiddler crabs, snails, and mussels; these organisms are, in turn, eaten by predators such as mud crabs, fish, rails, and raccoons. The remaining detritus, augmented by the dead matter from the primary and secondary consumers, is washed from the marsh by tidal action. This exported detritus, with material from submergent aquatic plants and the plankton, feeds the myriad of larvae and juvenile fish and shellfish which use estuaries, bays, and adjoining shallow waters. Marsh grasses may account for most of the primary production of the system in waters where high turbidity reduces light penetration, thereby reducing phytoplankton and submergent aquatic production.

(c) The rigorous environment of the salt marsh controls the number of animals living there. These areas are used by fur-bearing animals, such as the muskrat, nutria, and raccoon, and by birds such as herons, egrets, rails, shorebirds, raptors, waterfowl, and some songbirds. A much larger population of animals lives in or on the mud surface. The more conspicuous inhabitants are fiddler crabs, mussels, clams, and periwinkles. Less obvious but more numerous are annelid and oligochaete worms and insect larvae. In addition, larvae, juveniles, and adults of many shellfish and fish are commonly found in the marsh creeks.

(2) Introducing nuisance species.

(a) Although most coastal marsh species are highly regarded as ecologically beneficial, some are not. Common reed (Phragmites communis) particularly has a reputation in United States coastal areas as a nuisance plant. More literature is available on eradicating common reed than on planting it. It is purported to be of little direct value to wildlife and aggressively crowds out other desirable species. It grows in dense monotypic stands often to a height of about 10 feet (3 meters), which can interrupt views of the water and preclude public access. Because of these considerations common reed is usually not planted for shore stabilization in coastal areas even though it has demonstrated potential for this use (Benner et al. 1982). It is, however, planted at interior United States reservoirs and lakes for erosion control in drawdown zones (Allen and Klimas 1986).

(b) The introduction of nonnative species may also have negative impacts. Most marsh plants are aggressive colonizers. When introduced to regions where they do not occur naturally, they may spread rapidly in the absence of the diseases and predators which act as biological controls in their native environments. Introduced nonnatives may displace species which have ecological or agricultural significance. For this reason, careful consideration must be given before marsh plants are planted outside their natural ranges.

f. Recreation Considerations. Vegetative stabilization discourages certain recreational activities. Vegetation discourages public access for water-oriented activities such as swimming, wading, and sunbathing. In addition, vegetation discourages fishing from the shore; other shore protection structures often provide a platform for fishing use, and wave reflection may increase nearshore depths. Marshes may substantially increase the number of fish and wildlife in an area. As a result, nonconsumptive wildlife oriented recreational activities such as photography, observation, and nature study and consumptive uses such as fishing, bird hunting, and trapping are benefited.

g. Aesthetic Considerations. Marshes are a visual transition between land and water and a natural feature of the landscape adding form, color, and texture to the shore. Unlike other forms of shore protection, once plants are established no visible evidence remains to indicate that there has been a human effort to reduce erosion (Figure 6-2). In addition, the unique assemblage of birds and mammals associated with marshes are interesting subjects of photographic and illustrative art forms. Standard structural methods of shore protection may visually alter the shoreline (Figure 6-2), creating a barrier rather than a transition between land and water.

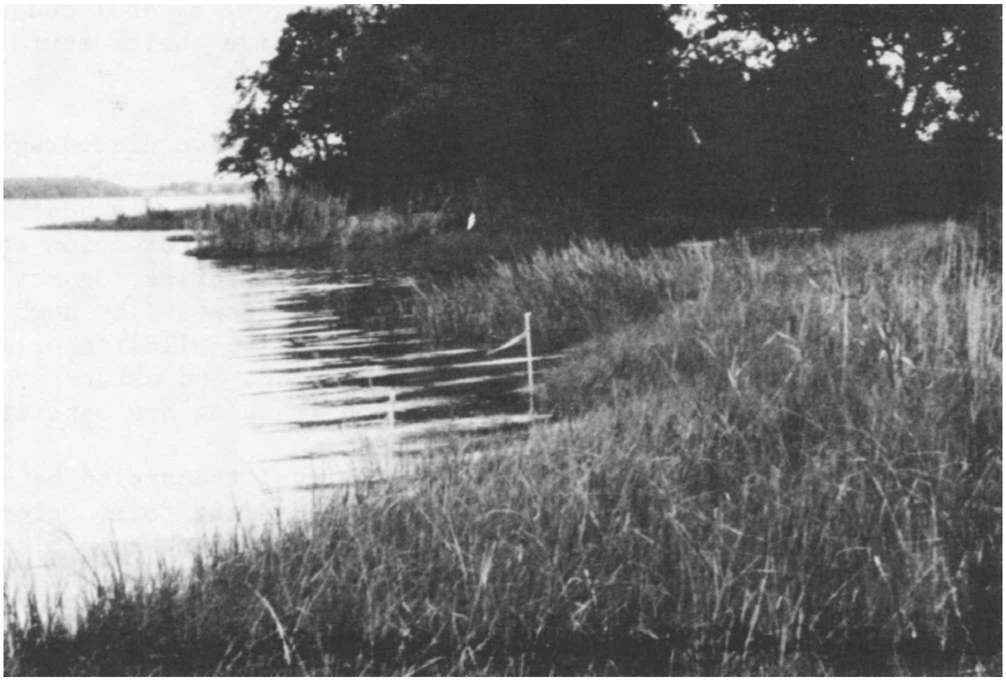
h. Summary.

(1) Establishing marsh plants to abate shore erosion generally will be considered as an environmental improvement. Positive water quality, biological, recreational, and aesthetic benefits are typically associated with vegetative stabilization projects. In addition, vegetative stabilization is the least costly of all erosion control measure. A 33-foot-wide, (10-meter-wide), (landward to seaward) shoreline planting requires an investment of only about $12 per linear yard (linear meter) to hand plant sprigs and about $28 per linear yard to hand plant nursery seedlings (based on labor costs of $15 per hour plus 100 percent overhead). Costs for structural alternatives will range from $50 to $1,000 per linear yard (Figure 6-3).

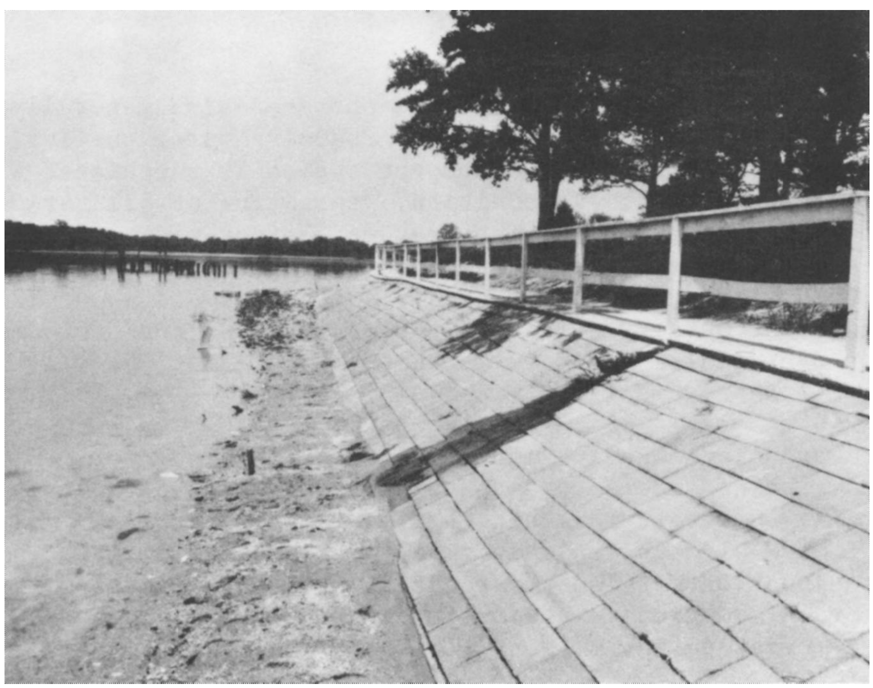
(2) Due to associated environmental benefits and low cost, this alternative should always be considered when shore protection is planned in sheltered bays and estuaries. However, this alternative is effective only within a limited range of wave climates and never on open, exposed coastlines, unless it is done in conjunction with energy-reducing structures. Refer to Knutson et al. (1981) for information on a simple method for evaluating site suitability on a "case-by-case" basis.

6-2. <u>Seagrasses</u>.

a. General. The establishment of seagrass meadows to aid in shore protection has only recently been recognized as a potential nonstructural



a. Vegetative erosion control project (Maryland)



b. Erosion control structure (Maryland)

Figure 6-2. Aesthetic comparison of nonstructural (salt marsh planting) and structural (revetment) measures

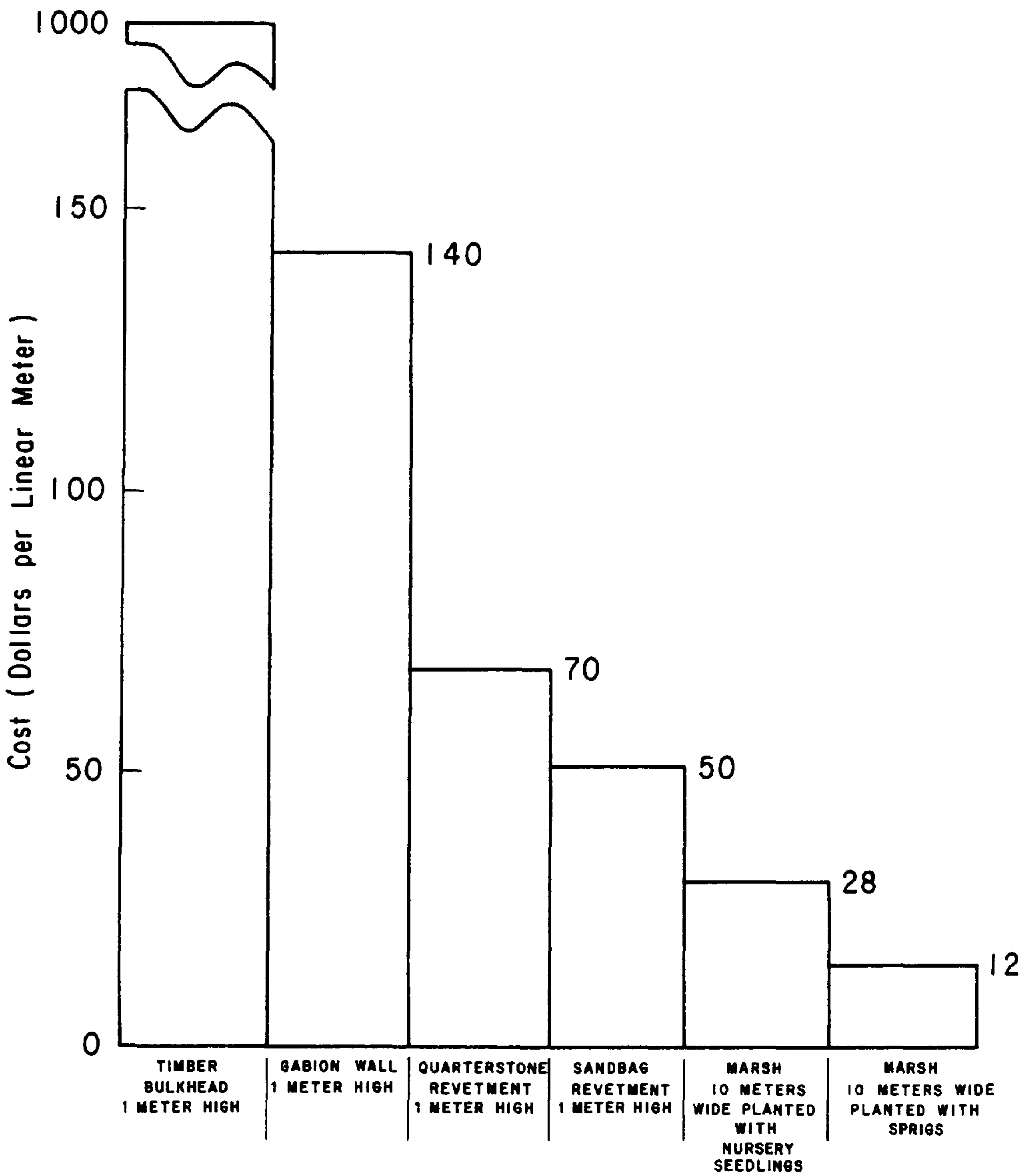


Figure 6-3. Cost comparison of alternative erosion control measures (after Knutson and Woodhouse 1983)

alternative. Restoration of seagrass for sediment stabilization and habitat enhancement is now possible due to recent developments in seagrass planting technology (Phillips 1980, Fonseca et al. 1982 and 1985).

(1) Seagrass meadows. Seagrasses are underwater marine vascular plants occurring primarily in shallow soft-bottom habitats and frequently forming extensive meadows. The plants can generally be characterized as having long, flat, grass-like leaves anchored to the sediment by extensive root and rhizome systems. Five species are common to the marine coasts of the United States--eelgrass (Zostera marina), widgeongrass (Ruppia maritima), shoalgrass (Halodule wrightii) manateegrass (Syringodium filiforme), and turtlegrass (Thalassia testudinum). Seagrasses normally occur in sediments ranging from sand to mud in relatively protected environments. Depth is limited to generally less than 10 feet (3 meters) by light attenuation in the water column. Salinity tolerance ranges from 20 to 40 parts per thousand (ppt), except for widgeongrass (0-15 ppt).

(2) Planting guidelines.

(a) Methods for transplanting seagrasses and guidelines for determining initial densities of transplants have been developed for most of the common species of seagrasses. Recommended procedures involve four relatively simple steps: obtain seagrass shoots from healthy donor beds by digging sods containing shoots, roots, and rhizomes; gently wash sediment out of sod; attach 5-15 shoots to wire anchors (Figure 6-4); and replant shoot bundles at designated site.

(b) Initially a seagrass transplant will consist of an array of shoot bundles arranged in a grid fashion with the individual bundles separated by areas of bare sediment. Coverage of the sediment will occur through lateral growth of the plants as new shoots develop runners in a similar fashion to plant spreading in strawberry patches. Depending on initial spacing, complete coverage may take one or more years.

(c) It should be noted that candidate locations for seagrass transplanting are limited by certain physical factors (i.e., large waves or low salinity). It is recommended that a monitoring survey be conducted before a decision to transplant is made. This survey should include measurements of depth, light penetration, salinity, temperature, erosion and deposition rates, currents, and wave conditions. Surveys should be conducted as frequently as possible and should encompass seasonal variation (Fredette et al. 1986). If the project is large, then it is prudent to establish and monitor pilot plantings before the full-scale project is begun.

b. Physical Considerations. Seagrasses are capable of dampening waves and currents, decreasing sediment transport, and protecting low-energy shorelines for erosion. These plants influence their physical environment by binding sediments with dense mats of roots and rhizomes and absorbing current energy via their flexible strap-shaped leaves (Figure 6-5). For example,

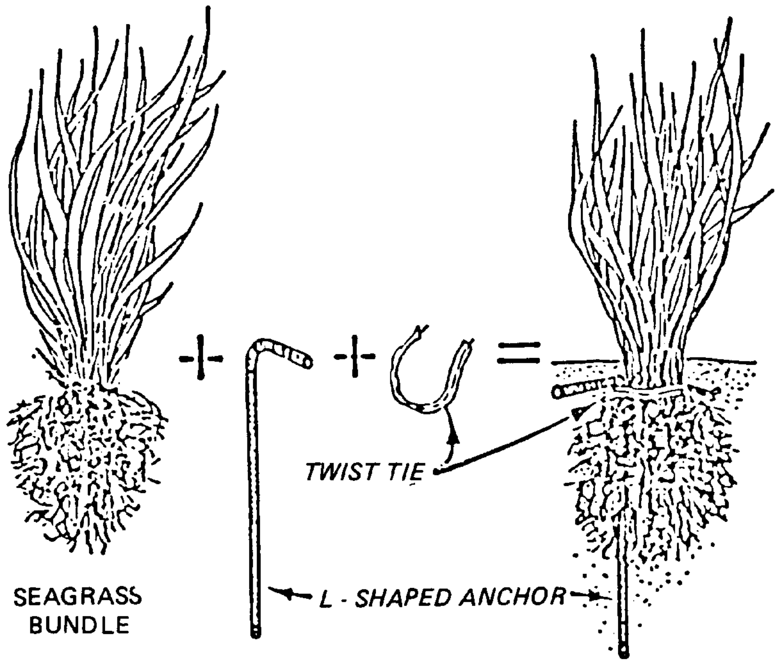


Figure 6-4. Typical seagrass and generalized method of making transplant unit.

Fonseca et al. (1982) report nearly 118 cubic yards (90 cubic meters) per hectare (2.5 acres) of sediment capture in a two-year old eelgrass planting.

c. Biological Considerations. Seagrass meadows serve as nursery sites and primary habitat for numerous fish and invertebrate species of both commercial and ecological importance and as feeding sites for wading birds and overwintering water fowl. Seagrasses are an important part of the food chain base, influencing estuarine and nearshore production well beyond the physical boundaries of the meadows.

d. Summary. Though seagrass meadows dampen waves as they approach the shore and capture sediments, seagrass plantings alone are seldom considered an adequate shore protection alternative. However, plantings can be a viable alternative when used in conjunction with other shore protection measures. Seagrass planting technology can also be used for the repair or replacement of seagrass meadows that have been damaged or displaced by the construction of other erosion control alternatives.

Figure 6-5. Sediment capture in seagrass meadow